ANTIAIRCRAFT ARTILLERY FIELD MANUAL

SERVICE OF RADIO SET SCR–545

CHANGES No. 2 } WAR DEPARTMENT, WASHINGTON 25, D. C., 1 November 1944.

FM 4–146, 2 November 1943, is changed as follows:

APPENDIX XI (Added)

MULTIPLE TARGET OSCILLOSCOPE INTERPRETATION

■ 1. PURPOSE.—Air forces of all nations commonly employ multiple aircraft formations in their tactical operations. It is essential that radar operators have a knowledge of how such formations appear in their oscilloscopes, which aircraft to track, how to estimate the number of aircraft represented, and the best method of tracking. This section discusses the technique of oscilloscope interpretation for double tracking radars, such as the SCR–545, which use type A presentation in range, azimuth, and angular height.

■ 2. GENERAL.—*a*. Before the study of multiple targets is started it is essential that radar operators be carefully schooled in the determination and visualization of where the electrical axis of their radar is with respect to other targets. As illustrated in figure 90 (a) and (b), a skilled operator should be able to visualize the position of the aircraft in space. As shown in figure 90 (c), (d), and (e), the radar is "on target" on aircraft *B*. Aircraft *A* is to the left of aircraft *B* in azimuth, above in angular height, and closer in range.

b. The operators should also be able to visualize the relative width of the SEARCH beam and TRACK beam so that the difference in SEARCH and TRACK oscilloscope presentation may be understood. Figure 91 shows that the SEARCH beam is broad and covers a relatively large part of the sky. The

TRACK beam is much narrower. Under many multiple aircraft formation conditions there will be more target echoes visible on the SEARCH oscilloscopes than on the TRACK oscilloscopes. The fact that the TRACK beam is narrow and gives better discrimination between targets is very useful. Figure 92 shows the range and elevation oscilloscope presentation for aircraft *A* and *B* represented in figure 91. From a study of these

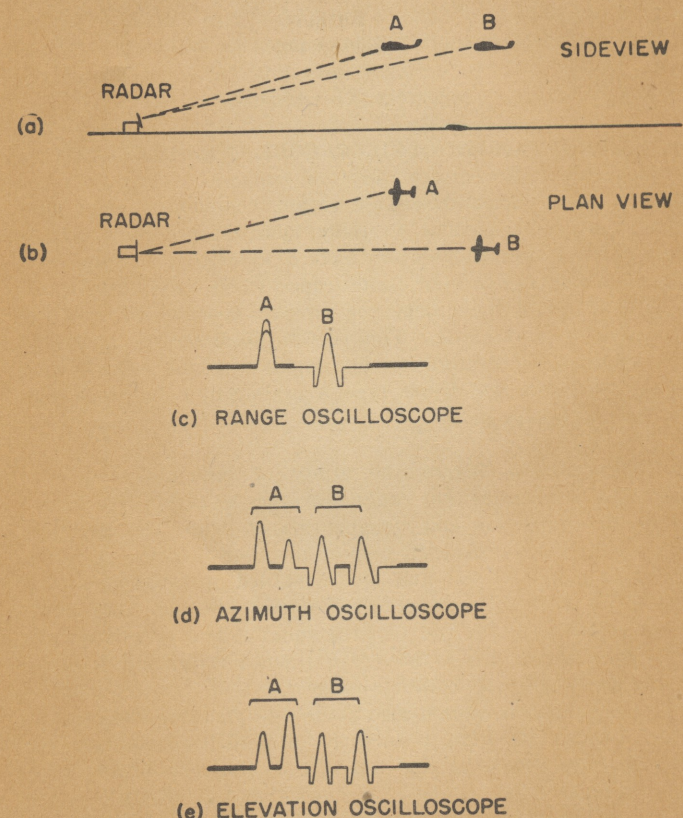

FIGURE 90.—Oscilloscope indications of targets.

two figures it may be seen that aircraft *B* is not hit by the TRACK beam, and, therefore, is not seen on the TRACK oscilloscopes. However, aircraft *A* appears on both SEARCH and TRACK oscilloscopes.

c. Under most multiple target conditions it will be necessary to dispense with automatic tracking and perform all tracking manually (or aided manually). This is particularly true when the formation is tight. If the formation is loose and wide, it is possible to use automatic tracking if there is only one target echo in the range notch. Operators can generally tell when an aircraft, in a loose formation, is about to interfere with the echo of the target being tracked by watching both the TRACK and SEARCH oscilloscopes. Aided manual tracking results in better data than automatic tracking when there is a tendency

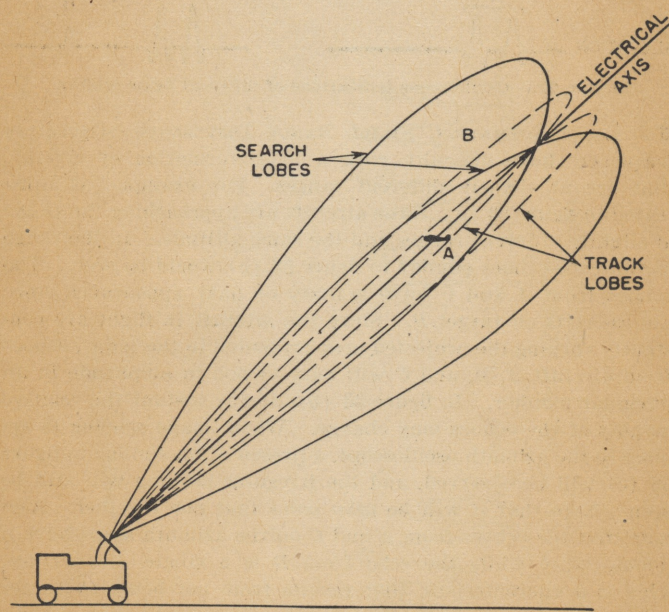

FIGURE 91.—SEARCH and TRACK antenna patterns in a vertical plane.

for the radar to jump or hunt from one aircraft to another in a formation.

d. In order to simplify the following discussion, interpretation of the TRACK oscilloscopes only will be covered since the TRACK scopes become most important in actually tracking targets and the SEARCH scopes present a similar picture.

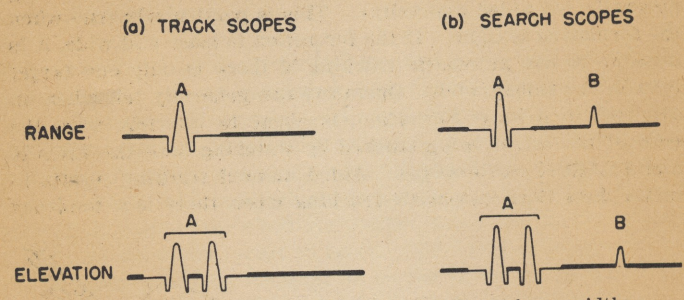

FIGURE 92.—Oscilloscope indications of different beam widths.

■ 3. LOOSE FORMATION, SMALL RANGE DIFFERENCE.—Operators frequently have difficulty with a loose formation of aircraft that are at slightly different ranges. For example, as illustrated in figure 93 (a), three aircraft are approaching the radar at slightly different ranges and the same altitude. In the range oscilloscope echoes similar to figure 93 (b) would be seen. The echoes from *A* and *C* have a fuzzy or hazy appearance since the radar is on target *B*. Since the aircraft in flight are constantly varying the projected area presented to the radar, echoes from aircraft *A*, *B*, and *C* will vary or bob in amplitude in an irregular manner. In figure 93 (b), at any instant the relative heights of the echoes may change. When image spacing is applied to the azimuth oscilloscope, a presentation similar to figure 93 (c) will be observed, and the irregular bobbing will still be seen. Note that it will be *echo pairs* that bob together. Also note that the echoes from *A* and *C* on the azimuth scope have a double trace while the echo from *B* is a single, clean trace. This is a characteristic that results from not being on target on *A* and *C* in elevation. The elevation scope will show a similar effect since we are not on target *A* and *C* in azimuth. If the echoes from aircraft *B* are matched, the echo pairs from aircraft *A* and *C* will bob together but keep their relative mismatch at a constant value. The important thing for the operators to gain from this study is that echo pairs will bob together even though they are mismatched. Whichever target the operators wish to track, the pair of echoes that bob together must be matched. Once again the necessity of the operators being able to visualize the position of targets in space is apparent in order to decide which target to track. The echo presentation in the elevation oscilloscope of the three planes shown in figure 93 (a) will appear as illustrated in figure 93 (d). Since the aircraft are at the same altitude and slightly different ranges, the angular heights will be different. As indicated in figure 93 (d), we are on target in angular height on aircraft *B* while aircraft *A* is above and aircraft *C* is below aircraft *B* in angular height.

■ 4. Tight Formation, Same Range.—Tight formations in which the aircraft are at the same range as indicated in figure 94 (a) give echoes which merge together to form one echo of increased amplitude. The upper portion of the single large echo will be hazy and will appear to flow up and down. The appearance of the oscilloscopes is shown in figure 94 (b), (c) and (d). It is not possible to distinguish between aircraft at the same range, and the tendency will be to track the center of small, tight formations.

■ 5. Wide, Loose Formations.—For wide, loose formations where the aircraft are spread in azimuth at different ranges, similar bobbing effects of echo pairs will be observed but the echoes will be spread out on the time base. Consider 3 aircraft in loose formation approaching a radar, as indicated in figure 95 (a). The oscilloscope presentation in azimuth is indicated in figure 95 (c). Once again the amplitude of the echoes will vary at irregular periods with respect to each other. Watching the echo pairs, match the echoes from aircraft *A*. Notice that the mismatch of the echo pairs from aircraft *C* is greater than the mismatch of aircraft *B*, indicating that *C* is at a greater

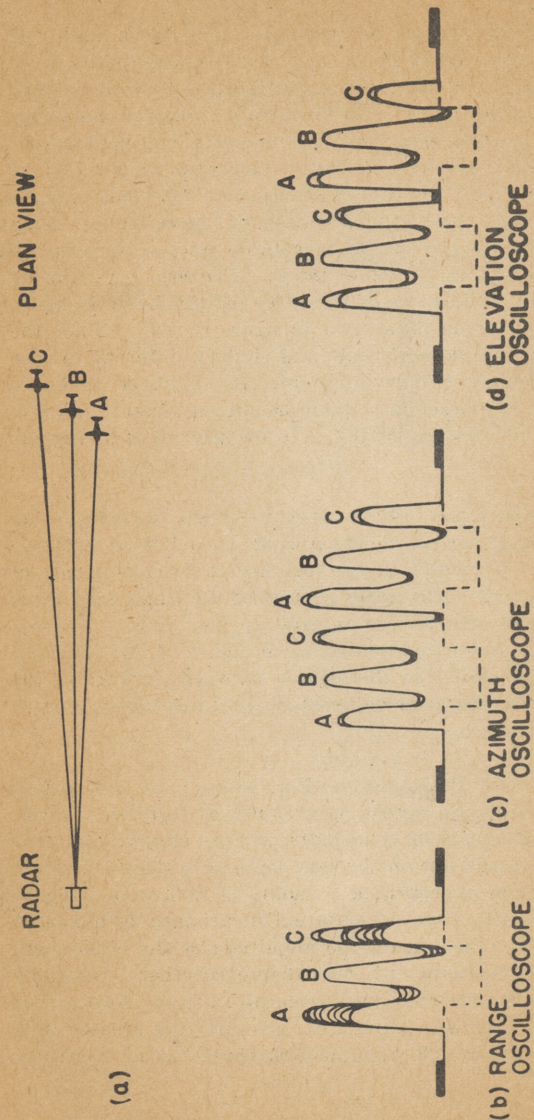

FIGURE 93.—Oscilloscope indications of a loose formation having small range difference.

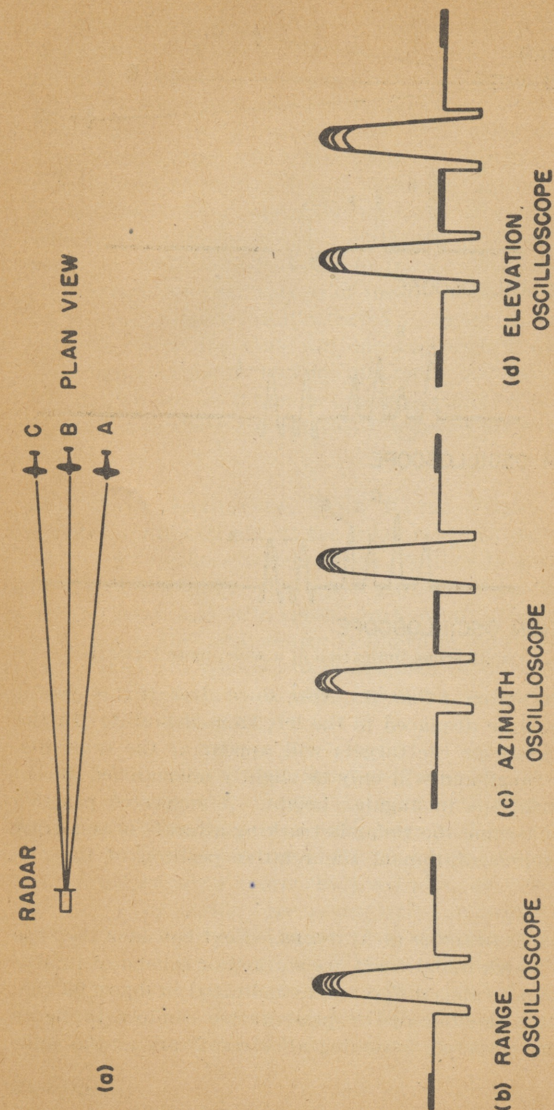

FIGURE 94.—Oscilloscope indications of a tight formation at the same range and altitude.

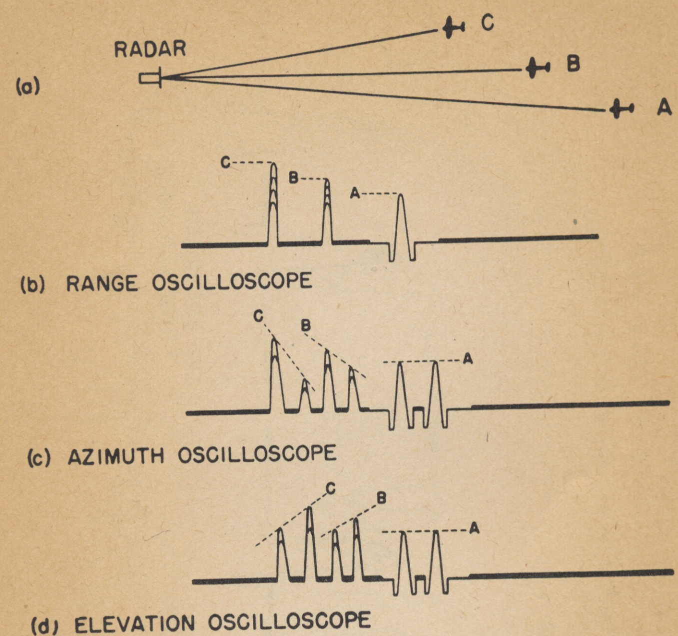

FIGURE 95.—Oscilloscope indication of a wide, loose formation.

angle to the left from *A* than *B*. Also, since aircraft *C* is closest in range, it will be displaced to the left from *B* and *A*. In the elevation oscilloscope the targets will appear at the same displacement in range and will only be slightly mismatched due to the small variations in angular height. A suggested practice example is to assume the radar is tracking aircraft *B* and draw oscilloscope representation of the relative position of the aircraft.

■ 6. AIRCRAFT ECHELONED IN ALTITUDE.—Next consider the type formation in which the aircraft are stacked or echeloned in altitude with a small range difference, as indicated in figure 96 (a). In the azimuth oscilloscope a presentation similar to figure 96 (c) will be observed, assuming all aircraft are at the same

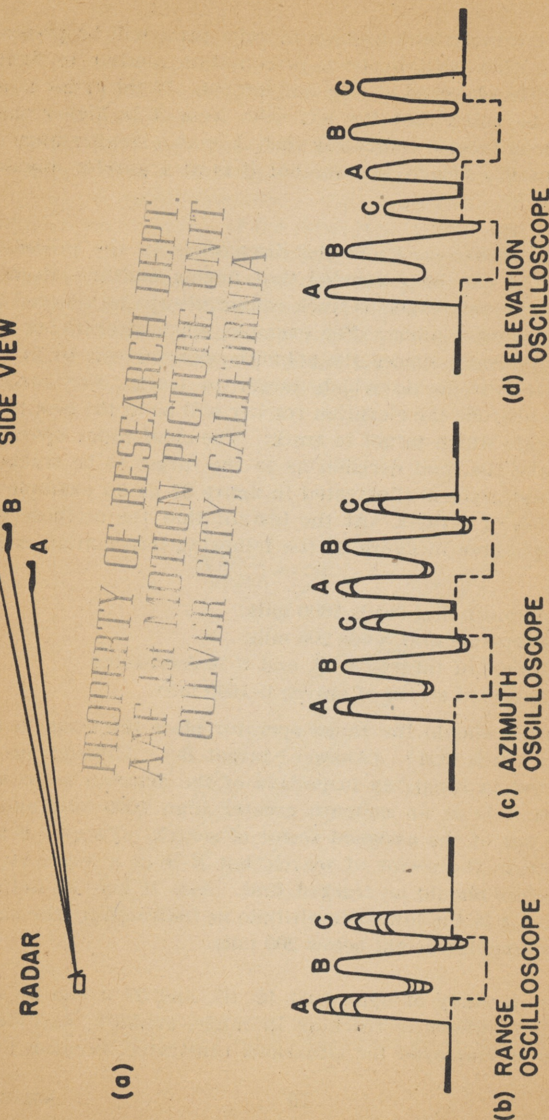

FIGURE 96.—Oscilloscope indications of a formation echeloned in altitude.

azimuth. Characteristic bobbing of echo pairs will be present. In the elevation oscilloscope a presentation similar to figure 96 (d) will be observed at any one instant. If the radar is on *B*, it will be noted that the left echo from *A* is higher than the right echo from *A* indicating that *A* is at a smaller angular height than *B*. Also it is seen that *C* is at a greater angular height than *B*.

■ 7. CONCLUSIONS.—*a*. From the discussions in the preceding paragraphs it can be concluded that during multiple aircraft attacks the proper target to track cannot always be selected by the range operator alone. For example, when aircraft are approaching laterally spaced the azimuth operator will be in the best position to decide which target to track. For targets stacked in altitude the elevation tracker will be in the best position to decide which target to track. The chief radar operator should make the final decision as to the target to be tracked. Consider the problem illustrated in figure 97 as an example in the selection of targets. At the instant that the oscilloscopes show the pictures in figure 97 the following information is obtained:

1. Azimuth dial reads 1600 mils.
2. Elevation dial reads 200 mils.
3. Range of targets *A*, *B*, and *C* is decreasing.
4. Assigned sector of search 0–1600 mils.

Which target should the range operator place the range notch under and track first? (Answer: target *B*.) Although target *A* is nearest in range, an inspection of the azimuth scope will show that *A* is at an azimuth greater than 1600 mils and is therefore out of the assigned sector of search. Targets *B* and *C* are both in the sector of search, but *B* is at a lesser range and therefore should be tracked first. Also it may be noticed that target *A* is the lowest in altitude as indicated by the short range and angular height below 200 mils.

b. From a study of figures 90, 92, 95, and 97 it can be concluded that automatic tracking in range, azimuth, and elevation may be employed for situations illustrated, because there

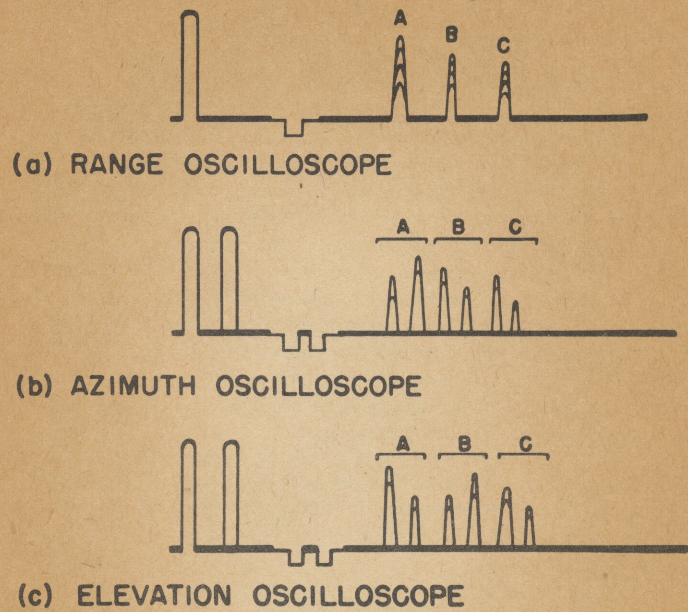

FIGURE 97.—Multiple target formation.

is enough difference in range between echoes so that one echo alone can be placed in the range notch. Aided manual tracking will probably produce better results for situations as illustrated in figures 93, 94, and 96 because more than one target echo is in the range notch.

c. An estimate of the number of planes in a formation can be made from a study of the oscilloscope presentations. However, an accurate estimate is difficult to make because of the various factors involved. At long range a tight formation of 3 aircraft may give a single large echo which approximates the echo from a single aircraft at shorter range. At short ranges it is somewhat easier to estimate the number of aircraft in a formation. Figures 93 and 96 indicate how the number of aircraft, with small range displacements, may be estimated. Experience is the best guide in making estimates. Since the

SEARCH beam is wider more target echoes will be visible on the SEARCH oscilloscopes.

■ 8. SUMMARY.—All radar operators should receive intensive training in oscilloscope interpretation; the ability to visualize the relative positions of aircraft in space and estimate their number. When several echoes, with small range displacements, appear on the oscilloscope the operator should know how to isolate the individual targets in terms of bobbing echo pairs. When several targets at different ranges and azimuths appear, the operators should know how to decide which target to track and the best method of tracking. For example, targets spread laterally are selected by the azimuth operator, while targets echeloned in altitude are selected by the elevation operator. The ability of radar operators to identify and isolate the proper target to track will materially help them track through various types of interference and jamming.

■ 9. REFERENCE.—See TF 11–1082, Oscilloscope Target Interpretation, on how to estimate the number of aircraft represented on type-A oscilloscope presentation.

[AG 300.7 (24 Oct 44).]

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IC 4: T/O & E 4–87;

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For explanation of symbols, see FM 21–6.

U. S. GOVERNMENT PRINTING OFFICE: 1944